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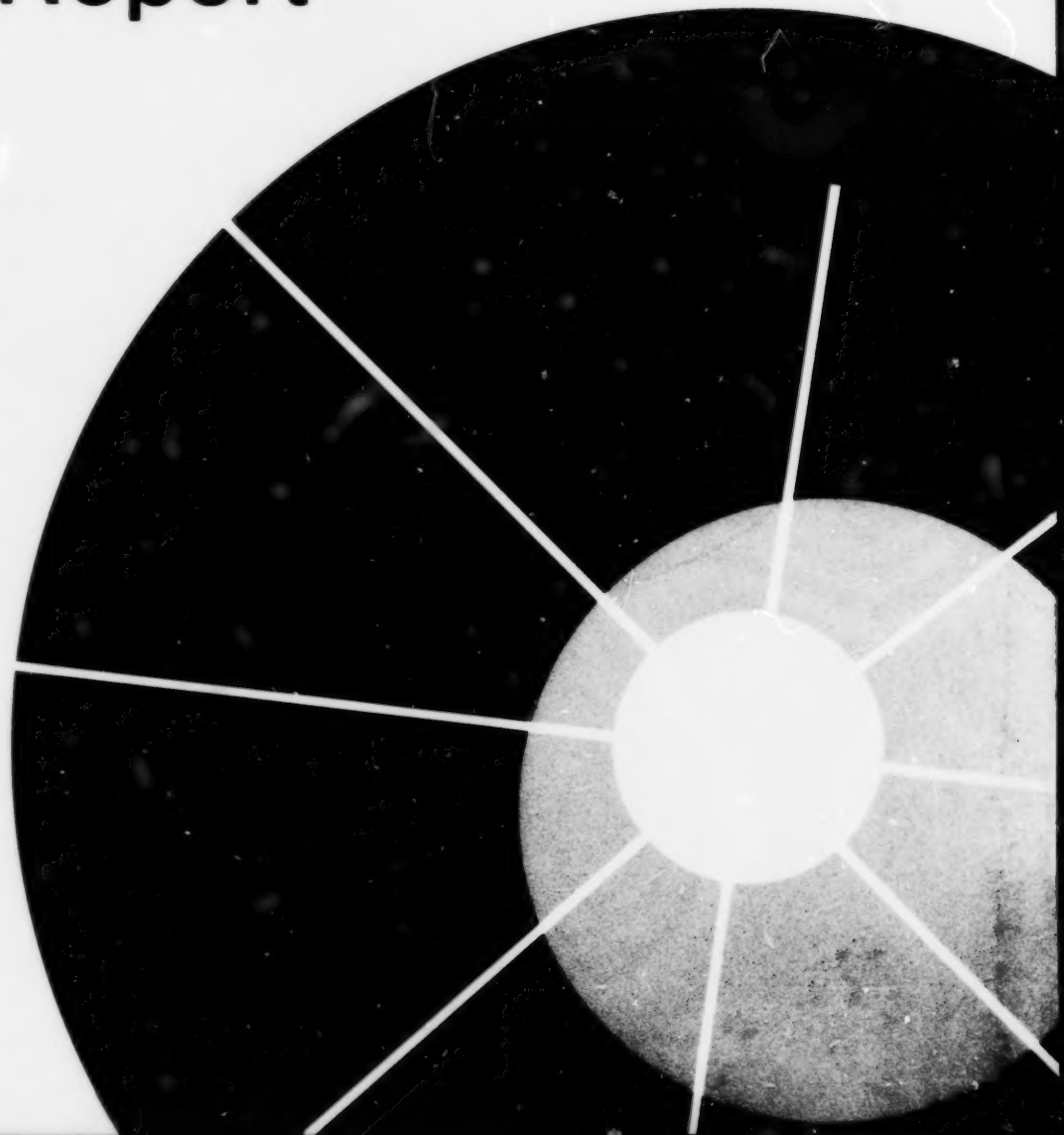
Canada - Saskatchewan Renewables — Conservation Demonstration Program

Final Report



CANADA-SASKATCHEWAN CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

On March 18, 1980, the governments of Canada and Saskatchewan entered into a Conservation and Renewable Energy Demonstration Agreement. The Agreement, which terminates March 31, 1984, funds the development and demonstration of a wide range of conservation and renewable energy technologies. The program is funded on an equal cost-shared basis by Canada and Saskatchewan, and is administered by Saskatchewan.

The objectives of CREDA are

- To develop and demonstrate promising new technologies which exploit renewable energy resources, conserve energy, or make its use more efficient.
- To create employment in new or existing industries.
- To develop broad public awareness of the potential of renewable energy and energy conservation technologies.

This report outlines the results of a project funded by the Government of Saskatchewan as represented by Saskatchewan Energy and Mines, and the Government of Canada as represented by Energy, Mines and Resources Canada, under the terms of the Renewables-Conservation Demonstration Program, and contracted with the party identified herein.

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Saskatoon Low Energy Market Housing Project

Final Technical Report
on a Renewables-Conservation Demonstration Program Project

Conducted By

Saskatchewan Energy and Mines

And Supported By

Saskatchewan Energy and Mines
and
Energy Mines and Resources Canada

Miscellaneous
Report FP-13

TABLE OF CONTENTS

Abstract	iii
Executive Summary	iv
Introduction	1
The Project	3
The Method	5
Project Origins and Design	7
Construction	9
Monitoring	11
Performance of the Project Houses	13
Demonstration and Technology Transfer	16
Project Impact	19
Conclusions	21

Appendices

A. Project Budget	23
B. House Design Criteria	24
C. Total Energy Use of Project Houses - prepared by R. S. Dumont, National Research Council	25
D. Specifications and Performance of the Houses	26
E. Weather Data for Saskatoon (lat 52° 6')	41
F. Low Energy Landscaping and Site Planning - prepared by D. Clark, Underwood McLelland	42
G. List of Papers and Publications relating to the Project	48

ABSTRACT

The report describes the Saskatoon Low Energy Homes Project, a group of 14 passive solar, low energy houses constructed by main stream building contractors. The primary objective of the project was to determine if conventional home builders could incorporate low energy techniques into conventional designs and produce low energy houses for the mass housing market. The successful performance of the houses proved that this was possible while the associated demonstration of the project helped make the public more aware of the possibilities of the new technology. Extensive monitoring of the houses provided important lessons for the improvement of the technology and sign posts for the further development of the field. The project also provided valuable data for the formulation of government programs and policies to encourage adoption of low energy housing.

EXECUTIVE SUMMARY

The Saskatoon Low Energy Homes Project was conceived as a logical follow-up to the low energy house experiment, the Saskatchewan Conservation House. While the Conservation House demonstrated the efficacy of the low energy features incorporated in its design, the project did little to convince the building industry that the ideas were applicable to mass market housing. Likewise, the public remained unconverted to the ideals of the decidedly unconventional house.

The Saskatchewan Government, mindful of the need to have the province's new housing stock meet future energy realities, initiated the Low Energy Homes Project to address these shortcomings. The project's main objective was to determine if the main stream building industry could incorporate low energy techniques into conventional designs and produce low energy houses for the mass housing market. The proposers also hoped to transfer the necessary technical knowledge to the building industry and to educate the public about the potential of low energy housing. Consisting of 14 passive solar low energy houses constructed by 13 of HUDAC-Saskatoon's member builders, the project ran from late 1979 to the completion of monitoring in March, 1982.

With the technical assistance of the Saskatchewan Research Council, National Research Council and the College of Engineering, University of Saskatchewan, the builders were able to erect a block of houses that required only 1/3 to 1/2 of the space heating energy of conventional houses. During the design, construction and monitoring of the houses a number of adjustments to building practices were developed, as well as the discovery of special problem areas in low energy housing. These included the failure of blown fibreglass attic insulation to provide rated thermal resistance, problems associated with heat loss through basement floor slabs, low efficiency of heat transfer from conventional furnace and duct systems, difficulties in the maintenance of air quality and ventilation heat recovery equipment, inadequate quality control on air-vapour barrier installation and the weakness of early models for calculating building heat loss. The lessons learned in the project have subsequently led to improved techniques in the building industry.

The demonstration of the houses for a two and half month period in late 1980 attracted over 45,000 people, including a large number of international visitors attending the concurrent Energy Show. While no major turnaround in public ideas about low energy housing can be attributed directly to the project there can be no doubt that the project provided many people with their introduction to the ideas and possibilities of low energy housing. A film, describing the features of low energy housing and the implications for the building industry, has enhanced the public information aspect of the project.

The transfer of technical knowledge to the building industry was another essential element of the project. Builders felt that there were some shortcomings in the limited technical training scheme incorporated in the project. Subsequent projects have improved on this aspect. On another level, the on-site experience gained in the project has been shared widely in the provincial and national building industry.

The project was a success. The mainstream building industry demonstrated its ability to produce marketable low energy houses. The successful performance of the project houses acted as a catalyst for a number of provincial and federal government programs designed to encourage the adoption of low energy houses. The house buying public has seen that low energy houses need not succeed at the expense of unconventional appearance or high cost and that they do not require a sacrifice in the quality of life.

Appendices attached to the report outline the project budget, specifications and performance figures for the houses, details of low energy landscaping and site planning, house design criteria and a list of papers relating to the project.

CREDA Report on Saskatoon Low Energy Homes Project
- The Energy Showcase -

Introduction

Energy has become a household word in Canada. The recent changes in world energy supply have forced us to think about how we use it. In Saskatchewan, a number of different strategies have been pursued to reduce our dependence upon oil products. In residential energy use, which makes up 20% of the province's energy requirements, Saskatchewan researchers have made major strides in the use of alternate energy sources and the conservation of scarce non-renewable energy supplies. The introduction of these new techniques to the mass housing market promises major savings in energy requirements.

The cold climate of Saskatchewan has always proved a challenge to the house builder. The provision of cheap energy however, mitigated most of the effects of the inappropriate technology used in prairie construction. With rapidly increased demand and diminishing supplies of energy, the basic economic forces ended the days of cheap energy. The resulting scramble for alternate energy sources produced a spectrum of responses. Researchers in Saskatchewan came to the conclusion that perhaps the cheapest form of alternate energy was conservation. A slightly higher initial cost of house construction would produce continuous dividends in reduced energy bills.

To further explore these ideas, the Government of Saskatchewan supported the construction of the Saskatchewan Conservation House. By identifying the different operating mechanisms working in the house the researchers were able to produce a high-performance energy-efficient product. The Saskatchewan Conservation House needed only 15% of the energy required by a conventional house for space heating. It proved to be a useful experiment. The house confirmed the value of the conservation approach with its stress on high insulation levels, complete air management and passive solar gain.

In spite of the success of the conservation features of the house, there was a hesitancy to accept them in the mass housing market. Builders were concerned that the construction changes required would be difficult to introduce to their standard practices. Even more important, would new house buyers be prepared to accept and pay for the extra costs associated with the conservation features? The public also had concerns. Most of the alternate energy houses to that point, and the Conservation House was no exception, had an unconventional appearance. Buyers were also wary about the extra cost of conservation. Would the energy savings be worth the higher price?

With an estimated 165,000 new residential housing units to be built in Saskatchewan before 2000, it became important to ensure that the conservation features were incorporated in them. The government supported the idea of a large-scale demonstration of energy-efficient housing to help make the features better known and more appealing to the industry and the public. This idea developed into the Saskatoon Low Energy Homes Project, one of the first CREDA projects in Saskatchewan.

The Project

Conceived by the Saskatchewan Government as a follow-up to the technical success of the Conservation House, the Saskatoon Low Energy Homes Project was designed to fulfill the marketing shortcomings of the original research demonstration project. The new project was to consist of a number of contractor built homes incorporating the successful energy efficient features of the Conservation House. In this way it would be possible to maximize public awareness of the possibilities of energy efficient housing and test their marketability. The overall objective of the project was to encourage the deployment of low energy residential units throughout the mass housing market.

The project proposers outlined several subsidiary aims in order to fulfill the primary objective.

1. The construction of low energy houses. Rather than pursue an active research and development program as was the case with the Conservation House, the project was to utilize the lessons of past research and lead to the construction of "state of the art" low energy residences. Complementary to the construction of the low energy houses the proposers hoped to investigate the principles of low energy land use planning and apply them where possible. If successful the completed houses would require only 1/3 of the energy consumed by conventional houses built to contemporary standards.

2. The erection of marketable houses. Cost-effectiveness of the low energy features of the houses had to be demonstrated. By building a number of different examples the project hoped to prove that the extra cost of the features would be paid for in energy savings in a reasonable time. Aesthetics of the houses would also be important. Conventional appearance was necessary to ensure wide-spread public acceptance. The project, by careful monitoring, would provide reliable and accurate data on the energy savings available to homeowners. This point was important in order to substantiate the researchers' claims. Finally, the living environment of the houses had to be guaranteed. Air management problems in the homes would have to be addressed and solved.

3. The transfer of technical knowledge to the building industry. By involving the builders, trades and suppliers in all aspects of the project the proposers had a dual purpose: to learn what difficulties might arise in the commercial application of the low energy features and to provide the building industry with the necessary assistance to overcome these problems and construct low energy houses.

The main items of concern in this area were:

- technical knowledge
- a demand for the finished low energy product
- minimum financial risk
- minimal disruption of construction practices and schedules
- assured supply of unconventional building supplies
- building trades trained in low energy building techniques

4. To inform and educate the public about the benefits of low energy housing. The project would include a major demonstration component with extensive distribution of information on both the construction aspects and the monitored energy performance of the houses. This activity was to stimulate a public demand for the low energy houses.

The Method

Saskatoon was selected as the site for the demonstration project. The proposers hoped to have the project houses open in conjunction with the meeting of Canada's provincial energy ministers and the Energy Show which were scheduled for that city in the fall of 1980. The high degree of interest by local builders was also a contributing factor.

The significant budget, over one and a quarter million dollars (Details of the project budget are given in Appendix A), and the many tasks that were a part of the project required the contributions and co-operation of a large number of groups. The main parties to the organization of the project were the Government of Saskatchewan, the Government of Canada, the City of Saskatoon, and both the Provincial and Saskatoon Councils of the Housing and Urban Development Association.

- Government of Saskatchewan - The provincial government provided one-half of the demonstration costs of the project, approximately $193,000, as provided by the Canada - Saskatchewan Renewables - Conservation Demonstration Program. A number of provincial government departments and agencies were also involved in the project.

    * Office of Energy Conservation - Saskatchewan Mineral Resources (now Saskatchewan Energy and Mines). The OEC was the originator of the proposal and was responsible for the demonstration and technology transfer components of the project. Sanderson, Ashby Consulting Ltd. was contracted by the OEC to co-ordinate the day-to-day operations of the project.

    * Saskatchewan Housing Corporation - The SHC provided the bulk of the finances for the project by making available $1,000,000 in direct mortgage loans to the builders. The staff of the corporation also undertook the required building inspections of the project houses.

    * Saskatchewan Research Council - The SRC acted as the provincial government's technical consultant to the project.

- Government of Canada - The federal government contributed one half of the project demonstration costs, approximately $193,000, as provided by the Canada - Saskatchewan Renewables - Conservation Demonstration Program.

- The City of Saskatoon - The City provided 14 lots in the Lakeview subdivision for construction and set aside two additional blocks of lots for parking space. The City

further agreed to prepare and gravel the parking areas.

- The Housing and Urban Development Association of Canada - Provincial Council - HUDAC-Saskatchewan acted as a liaison body between the provincial government and the building industry during the planning of the project.

- The Housing and Urban Development Association of Canada - Saskatoon - The member builders of HUDAC-Saskatoon constructed the homes in the project. The builders in the project included:

  - Amber Homes Ltd.
  - Cairns Homes Limited
  - Concept Construction Ltd.
  - Hilton Homes Ltd.
  - Medallion Homes Ltd.
  - Milbrandt Homes Ltd.
  - Nu-Central Homes Ltd.
  - Plainsman Developments Ltd.
  - Rathgeber Homes
  - Schurman's Construction Co. Ltd.
  - Shir-Lee Homes Ltd.
  - Stellar Developments Ltd.
  - Victory Homes

- The National Research Council of Canada - Prairie Regional Station of the Division of Building Research was contracted by HUDAC-Saskatoon to provide technical expertise for the builders.

- The Department of Mechanical Engineering, University of Saskatchewan was responsible for the detailed monitoring of the project houses.

Project Origins and Design

In late 1979, the SHC and OEC approached the Provincial Council of HUDAC with the idea for a low energy housing demonstration project. The government agencies suggested that the demonstration project would be a good theme for the HUDAC Parade of Homes, an annual showcase for the Saskatoon residential building industry. Initial discussions went smoothly and a management committee was set up to organize the project. Further discussions, which included HUDAC-Saskatoon, led to a call for submissions from builders interested in participating in the project.

The general designs received were judged by standard selection criteria, including an assessment of the suggested plan and a review of the builder's construction experience, reputation and financial capability. Thirteen builders were accepted for the project. One builder had two plans accepted, thus bringing the project total to 14 houses.

After initial acceptance the contractors moved onto the detailed design stage. In order to achieve the low energy targets set by the project the contractors were given some guidelines. Rather than prescribe insulation levels and other mandatory low energy design features, builders were provided with broadly stated design objectives. The one exception was the energy budget; the project organizers hoped to heat the demonstration houses for less than $100 a year (The detailed design criteria are summarized in Appendix B). Builders were also required to submit the same house plan and its costing without the extra low energy features so that a cost comparison and cost-effectiveness table could be set up. A technical committee made up of representatives from the SHC, SRC and NRC studied the plans and ensured that they would meet the program objectives.

The detailed designs for the project were done in the spring of 1980. All of the designs utilized the main features of low energy housing: high insulation levels, an effective air-vapour barrier coupled with a heat-recovering air management system and the maximization of passive solar gain. Some builders also included special features such as trombe walls, night shutters, attached sunspaces, air lock entrances, air-tight furnace rooms and alternative heating systems (Details on the house features are presented in Appendix D).

It was in this stage that the building industry ran into the first difficulties associated with the low energy technology. During the review of the detailed plans in April the technical committee noted that a number of shortcomings were common to most of the plans. These included:

1. The possibility of ceiling sag. With widely spaced rafters and high insulation loadings there appeared to be a chance that ceiling drywall would deform.

2. The lack of details for the installation of the air-vapour barrier. The critical importance of the integrity of this feature required considerable detailing in the drawings to ensure that it was installed properly.

3. The use of air-tight furnace rooms. The limited information available on the operating characteristics of this feature caused some difficulties, which would be compounded later by the low heating requirements of the finished houses.

4. The use of double or composite walls. In order to achieve the higher insulation levels required for the project thicker walls were specified by builders. However, many failed to foresee the possible construction difficulties that might occur at corners and did not include relevant details.

Most of these difficulties were solved in the design stage.

In May, construction of the 14 houses began on the designated site in the Lakeview subdivision.

Construction

The construction phase of the project went very well. The close co-operation between builders, technical experts and the trades kept problems to a minimum.

The NRC prepared and delivered a number of detailed seminars to the contractors on the technical aspects of low energy housing. These were well received but proved to be insufficient to meet all the information needs of the house builders. The lack of general information on the principles of low energy housing led to some problems on the job site. Contractors were often unaware of the theoretical background to the changes in building techniques. The difficulties of incorporating the new features into the building industry techniques were expected and while some frustration and reworking resulted, no serious challenges were left unmastered. The subsequent R-2000 program profited from the Showcase experience and placed extra emphasis on its education component.

The houses were completed and appropriately landscaped in time for the beginning of the demonstration phase in October, 1980 (See Appendix F for details of the low energy landscaping principles utilized in the project). The houses represented significant advances over the conventional construction standard and promised major savings in their energy requirements. The technical specifications are summarized in Table I (See Appendix D for the insulation and performance details on each house).

Table I

SUMMARY OF CONSTRUCTION STANDARDS USED ON PROJECT HOUSES

ITEM	AVERAGE	PROJECT RANGE	1980 NORMAL
Appraised Value of House	$83,820	$73,720 - $102,775	$78,245
Incremental Building Costs	$ 5,575	$ 2,250 - $ 10,500	0
% Incremental Costs	6.7%	2.9% - 13.6%	0
Nominal Area (m^2)	104.6 m^2	64.2 - 130 m^2	N/A
Nominal Insulation Levels (RSI)			
- Walls	6.6	5.3 - 10.6	3.5
- Ceiling	9.3	7.0 - 10.6	6.1
- Basement Walls	5.2	3.5 - 6.7	1.4
- Basement Floor	0	0	0
Windows - South (area/glazings)	9.9/2.86	6.3/2 - 16.4/4	N/A/2
- Non-S (area/glazings)	3.8/2.93	2.1/2 - 7.3/4	N/A/2
Air Infiltration (ACH at 50 Pa)	.85	.39 - 2.19	3.8

Monitoring

The primary aim of the project was to determine if conventional home builders of the mainstream construction industry could produce low energy houses. The detailed plans for the project houses were subjected to close scrutiny by the various technical experts of the SRC, the College of Engineering of the University of Saskatchewan and the NRC. Complete heat loss calculations were also done for each house. However, the most effective argument to convince the public would be the actual energy bills. Therefore the project included a major monitoring effort to compile reliable performance data.

Monitoring also served an important scientific function. While it was obvious that the combination of low energy features produces savings in energy use, it was critical to know how much each component contributed to this improved performance. The improvement of design relies on detailed information outlining where energy is lost and where it is gained. Monitoring provides this information and enables the researchers to learn more about the energy dynamics of house operation.

The monitoring program included the following elements:

1. Air infiltration testing determined the relative air tightness of the air-vapour barrier. This was done by researchers from the NRC using an air infiltrometer developed in the Prairie Regional Station of the NRC's Division of Building Research (See Appendix D for the results of these tests. Further information on the air infiltrometer is available in H. W. Orr and D. A. Figley, "An Exhaust Fan Apparatus for Assessing the Air Leakage Characteristics of Houses", NRC-DBR, 1980, BRN No. 156).

2. Thermographic scans were done to measure heat loss and point out thermal weak points in the building shell.

3. Meteorological data including temperatures, winds and solar radiation was collected at the site to provide details of the climate in the immediate area of the test houses.

4. The actual gas and electrical usage for each house was audited throughout the monitoring period.

5. Special monitoring devices were installed in the houses to gain detailed information on specific aspects of the operational dynamics of the houses.

The monitoring program produced a number of worthwhile conclusions. Without such detailed work, many of the lessons gained from the project would not have been learned and much that

has since been incorporated in low energy construction would still be experimental in nature.

Performance of the Project Houses

The project houses achieved major savings in the use of energy for space heating. The extensive monitoring of the project after the homes were occupied proved the value of the low energy techniques and showed that low energy housing could be built for the mass housing market by the mainstream building industry. However, a number of problems were uncovered. These led researchers to recommend design and materials modifications to enhance space heating performance still further.

The net annual space heating target of the project had been 20 GJ per 100 m^2 (33.3 KJ/[DD-m^2]) of heated floor space. This amounted to a reduction of between 50 - 70 % of the space heat requirements of houses built to the contemporary standards. The technical committee had done extensive computer modeling of the detailed plans to ensure that this target would be achieved. The calculations showed that 11 of the houses were well below the space heating objective, while the remaining three were just over it. The range of estimated space heating requirements went from a stingy 7 KJ/[DD-m^2] to a still respectable 40 KJ/[DD-m^2].

The monitoring of the houses, undertaken from March, 1981 to March, 1982, however, produced different results (See Appendix G for a complete list of the reports of the monitering). While the space heating performance was still well below that of conventional construction, the actual energy consumption of the houses was significantly higher than calculated. Only two of the houses actually achieved the space heating objective of 33.3 KJ/[DD-m^2]. Two others were just over it. The monitored range of space heating requirements was 24.9 KJ/[DD-m^2] to 85.4 KJ/[DD-m^2]. Conventional designs required between 67 KJ/[DD-m^2] and 100 KJ/[DD-m^2].

The researchers investigating this performance discrepancy discovered a number of problem areas. Some of the problems were solved quickly, while others introduced the scientists to whole new fields requiring further research. The most significant weaknesses included:

1. Blown fibreglass insulation used in the attics of most of the houses performed well below design specifications. Heat loss through the attics was several times that predicted. Tests at the University of Saskatchewan showed that the actual insulating value of the material was only 1/3 to 1/2 of that claimed by the manufacturer. The researchers found that as the temperature difference across the layer of insulation increased, the apparent thermal resistance was reduced. They theorized that this was due to air movement

within the insulation which resulted in greater net heat transfer through the material. One manufacturer withdrew the insulation from the market and has replaced it with an improved product. The houses with the poor insulation were subsequently retrofitted with the more effective insulation.

2. High heat loss through the basement slabs was another problem. With conventional construction, slab losses are insignificant when compared to the rest of the building losses. However, in the project houses the rest of the building had been improved to such an extent that while the slab lost no more energy, it had become a major source of heat loss. Additionally, the researchers found that energy losses through slabs were two or three times higher than originally calculated. This finding manifested itself as uncomfortably cool basements in the houses. This was especially pronounced in the late summer when some of the houses were subject to solar overheating. While use of the furnace fan to circulate air alleviated the problem, it did lead to increased electrical energy usage. Researchers have identified the problem and research to reduce basement floor heat loss is beginning to supply some answers.

3. The heating systems used in the project generally consisted of a conventional natural gas forced air furnace and duct system located in an exterior vented sealed furnace room. Monitoring of the total heating systems revealed very low living area space heating efficiency. These results led to serious questioning of the utility of the conventional furnace - sealed furnace room combination for low energy houses. Researchers suggested that the development of new, more appropriate heating systems would be more successful than continued adjustment of existing systems.

4. The air management systems used in the houses represented the leading edge in residential low energy technology. Not surprisingly, the systems led to a few problems. The major component of the system, the air to air heat exchanger, was in a developmental stage and a number of design, installation and operational errors occurred in the project houses. The main problem concerned the balancing of the air flow rates between the exhaust and fresh air intakes. This difficulty was often compounded by homeowners who were unaware of the proper operating method for the exchangers. Since these operational difficulties reduced the effective air change rate in some houses, air quality suffered to a certain extent. A few houses had very high relative humidities and in some cases formaldehyde gas reached pronounced concentrations. However, once air management installations had been corrected and improper operating habits rectified these problems were overcome. (The

National Research Council - Division of Building Research conducted a number of air quality tests during the monitoring period. The results of these tests have not been published but were discussed during the preparation of this report.)

5. Air infiltration, one of the keys to successful low energy housing, remained a problem for a few of the builders. Improper attention to air-vapour barrier installation and sealing resulted in somewhat less than optimal performance for some houses. While still ahead of conventional construction, this experience pointed out the necessity of care and attention to detail in the construction phase.

6. Operation of the houses also led to wide variations in energy use. Homeowners were often unaware of the proper operating method for some new systems, such as the air to air heat exchanger. As well, the failure to implement small lifestyle changes such as night thermostat setback and limiting the opening of windows during the heating season, meant higher energy usage. Appliance selection for the homes does not appear to have reflected a desire to select low energy items. The need to continuously operate furnace fans to maintain even temperature distribution throughout the house also contributed to higher than expected energy requirements in a few of the houses.

7. Perhaps the most frustrating problem uncovered by the monitoring researchers was the weakness of their energy use models. Traditional heat loss methods failed to accurately predict space heat requirements, the solar models used appeared to over-emphasize the value of passive solar gain and by reducing conduction heat losses to such low levels, the researchers found that a number of more subtle forces began to have an increasingly significant impact on the energy flows in the house. One researcher summed up the difficulty when he wrote; "our present knowledge of [low energy] components is often inaccurate to the point that the ensuing errors would lead to large errors and incorrect conclusions about the effectiveness of the components and about the house as entire thermal systems... In short, we have taken on the task of studying what everyone intuitively understands, because they live in [a house], and found a whole research area where the answers to one question leads to other questions and where very little of the traditional knowledge can be accepted at face value." Subsequent adjustments to heat loss models have now removed much of the uncertainty in calculating heating requirements.

Demonstration and Technology Transfer

The technical achievements of the project would be worthless if the results were not made known. Two of the project objectives revolved about the successful transfer of information to both the house-buying public and the house-building industry.

One of the project aims was to inform and educate the public of the effectiveness and value of the low energy features. The achievement of this objective would ensure the development of a market for low energy houses.

Equally important was the transfer of the low energy technology to the building industry. By supporting the industry in its initial work on low energy houses, the project allowed the builders the opportunity to uncover any variations from standard construction schedules and materials. The experience also offered on the job training for the industry, from contractors, to suppliers, to tradesmen. This enabled the industry to acquire the skills required to meet the market demands for efficient and cost-effective low energy housing.

Public Demonstration

In order to reach as broad an audience as possible for the project, the Office of Energy Conservation commissioned Camera West, a Regina based film company, to produce a 14 minute 16 mm film. The film shows how livable design and energy conserving features can be combined to produce a low energy house. Builders, researchers and government representatives comment on the significance of the project.

The public demonstration of the project houses utilized the news media, open houses, special tours, advertising and the distribution of information packages to convince the public of the value of low energy houses. The project coincided with the HUDAC-Saskatoon annual Parade of Homes demonstration.

The major demonstration feature of the project was the open house aspect. From October 3 through December 21, 1980, the houses were opened to public viewing. Encouraged by an extensive advertising campaign in both the print and radio media, over 45,000 people visited the houses during this demonstration period. As the project demonstration was jointly administered by the builders and the Office of Energy Conservation, the open house program was split between them. The builders were responsible for the initial two weeks, the traditional Parade of Homes display period. During this time, the houses were staffed by real estate agents. Production delays limited the amount of informative material and displays available during this period. Consequently,

the first two weeks of the demonstration focused on the decorative features of the homes.

Tour guides, specifically hired and trained to answer queries about the low energy features, proved much more successful during the subsequent extended demonstration period. The gradual addition of explanatory display panels, wall section models, a slide show and the information packages all enhanced the display value of the open house period. While many visitors were initially attracted to the project because it was the annual HUDAC Parade of Homes, most became interested in the low energy features once they were pointed out. In this way the project acted as an introduction to low energy housing for many people.

The project demonstration period was concurrent with The Energy Show, an international symposium on the future of world energy use and a meeting of the Provincial Energy Ministers. These two events prompted a number of special tours of the project by participants. In this way the project was given a form of international exposure and both the Saskatchewan Government and the provincial building industry gained the approbation of a wide range of energy experts.

Media coverage of the project was somewhat less than had been hoped for. While the local media was enthusiastic in its support and coverage of the project, there was very limited interest by the national media. Only a few articles on the project were published in a number of specialty magazines (Appendix G lists papers and articles on the project).

Industry Technology Transfer

The other target group for information transfer was the building industry itself. While the low energy techniques were really only modifications of standard building practice, they did require some significant alterations in construction scheduling and attention to detail. The technology transfer effort supplied information to both the local construction industry and to a national audience of residential builders.

The construction phase of the project provided the local builders with the opportunity to study and practice the new techniques. Specialized training in the new techniques was limited to a seminar for the building contractors and a workshop for the building trades. Although these seminars provided information on some of the technical requirements for successful low energy housing, time did not allow for more thorough job specific training. This shortfall was most apparent among the tradesmen and on-site supervisors and has hampered the subsequent

diffusion of the techniques through the local building industry.

On a national level, Sanderson, Ashby Consulting Ltd. produced a slide tape show on the project for HUDAC-Saskatoon. This show, a large display and a number of presentations were made to the HUDAC National Convention in Montreal in February of 1981. Subsequently, the Parade of Homes presentation was invited to participate in a number of low energy seminars for building contractors across the country. In this way many of Canada's residential builders were exposed to the lessons of the project. Much that was learned in this project has since been incorporated in the joint Federal Government/ HUDAC R-2000 low energy house program.

Low energy landscaping also received attention. Douglas Clark of Underwood McLelland produced a detailed study of the possibilities of energy conscious landscape and urban site design.

A number of awards were presented to the organizers and participants of the Energy Showcase project. In 1981, the project received the HUDAC National Award for Community Service at the annual HUDAC Convention in Montreal. The following year the project participants were also awarded the Canadian Housing Design Council Award.

Project Impacts

The project had a number of important impacts on the technology used by the building industry and the formulation of government programs and policies. These impacts represent spin-offs over and above the project's objectives.

While low energy housing technology does not require major re-adjustments in the working method exercised by builders, it quickly became apparent that major changes were needed in the institutions and policies related to building construction. Regulatory bodies have developed housing standards from the construction of conventional 2 X 4 stud frame houses. Variations that include much higher insulation levels, thicker walls, air-tight construction and have as a primary aim low energy consumption as opposed to low construction costs, mean that the infrastructure based on the latter would require some adjustment. This proved to be true in a number of cases.

The poor performance of the blown fibreglass attic insulation is an example. At first glance, it appears that the company was merely peddling an inferior product. However, the product met or exceeded all government specifications for that product. Obviously, testing standards and regulations require upgrading.

Building codes are another case where adjustment is required. The location of air-vapour barriers inside the double or composite walls was in direct contravention of the wording of the building code. The spirit of the code however was maintained by ensuring that the vapour barrier remained on the warm side of the dew point. Additionally, the whole question of air quality in housing has never been incorporated in any code. With modern building techniques it is possible to control air infiltration and make use of mechanical ventilation and heat recovery systems. Problems associated with this type of equipment in the Energy Showcase highlight the need for codes and standards to govern household air quality and related equipment. Steps in this direction are proceeding. A successful example is the acceptance by the R-2000 program of the energy budget, first used in the Energy Showcase. The prescription of required insulation levels is no guarantee of low energy performance and the use of the energy budget is a recognition of this fact.

Present tax assessment methods use the exterior measurements of a building to determine its tax value. Low energy houses, with their thicker walls and consequently smaller interior area, suffer a tax disadvantage. Opinions on the justice of this method are divided between those that say that the low energy houses are worth more and thus should be taxed at a higher rate and those that argue that the low energy home owner is merely paying for his

fuel in advance and should be given a discount for the thicker insulation.

Low energy homes are quite different from conventional ones and changes in the institutions governing housing will no doubt follow as increasing numbers of low energy houses are built. Progress has already been made.

The successful performance of the Energy Showcase has also encouraged city planners to include site planning details and solar access as important components in future developments.

Conclusions

The Energy Showcase project's main objective was to introduce the mainstream building industry to the new techniques of low energy construction. Subsidiary to this main objective were four aims: the construction of low energy houses, the erection of marketable houses, the transfer of technical knowledge to the building industry and education of the public.

The first aim of the project was the erection of low energy houses. While not all of the houses were able to achieve the originally anticipated target of a $100 space heating bill, the project houses were a significant advance over conventional housing. Space heating requirements were only 1/3 to 1/2 of conventional housing. There can be no doubt that the project proved to builders, the house-buying public and the government that low energy mass housing was possible. The technical success of the project had immediate results. The building industry quickly adopted some of the more easily incorporated aspects of low energy housing and began the serious consideration of the others. Both the Federal and Saskatchewan governments acted to establish incentive and education programs to encourage the adoption of low energy houses. The Federal government implemented the R-2000 program jointly with HUDAC to demonstrate the advantages of low energy housing across the country and the Saskatchewan government introduced the Home Energy Loan Program (HELP) to ensure that a substantial proportion of new houses would meet low energy standards.

Once on the market the project houses were quickly sold. The publicity surrounding the houses and the promised performance proved to be attractive features for buyers. However, marketability is based not on individual showcase houses, but rather on the ability of the contractor to continue selling a similar product. Some of the builders became frustrated during the construction of the showcase homes. The lack of general training in the principles of low energy construction prevented them from completely understanding and controlling the process of house design or construction. Costs were generally higher than anticipated and several builders were unable to make an economical entry into the low energy market. This resulted in a rejection of the idea and a return to near conventional methods. Other builders, however, successfully assimilated the lessons of the researchers and were able to produce a profit-making product. They have remained in the low energy field and have participated in the federal and provincial government's low energy housing incentive programs. The Energy Showcase offered Saskatoon builders the opportunity to enter the low energy housing market. Not surprisingly there were a variety of responses from the builders. However, the fact that several of the participating Saskatoon builders are presently building only low energy houses

is an indication that the project achieved its second aim, tc have the main stream building industry produce marketable low energy houses.

The transfer of technical knowledge to the building industry was not as successful as the first two aims. There was no comprehensive training plan included in the project and consequently neither the builders nor the tradesmen were able to fully comprehend the ideas behind low energy housing. Without understanding the principles behind the low energy techniques, it is difficult to implement them successfully. The weakness of the training scheme may partially explain why not all of the builders were converted to low energy construction. The R-2000 program drew on the experience of the Energy Showcase in this respect and a large proportion of that program's budget is dedicated to the educational component. The Energy Showcase provided lessons in the requirements for a successful information transfer program.

The fourth aim was to educate the public about the possibilities of low energy housing. The project did not immediately convert the house buying public. Its effect was more a denting of consciousness. In the process of creating a market for low energy houses the project was a valuable early step. The impact of the project in this regard may have been hampered by the lack of publicity after the monitoring period had provided proof of the success of the houses. In spite of this weakness however, there can be no doubt that the Energy Showcase provided many people with their first taste of the new low energy technology.

The Energy Showcase, by fulfilling the subsidiary aims of the project, achieved its primary objective. The project decisively proved that the main stream building industry could adjust its techniques to produce marketable, low energy houses for the mass housing market.

Appendix A

- Project Budget -

(1) Design and Construction Support (SHC)

- project management	$ 15,000	
- technical advisory and builder overhead ($7,000/house)	98,000	
- Total design and construction		$ 113,000

(2) Demonstration/Information/Education Support (DMR)

- project management	12,500	
- publicity/advertising	30,000	
- information/education materials		
* brochures, fact sheets,report	35,000	
* film	30,000	
- demonstration		
* staff	24,000	
* displays	30,000	
* house leases	47,250	
* reception area, misc.	15,000	
- monitoring	45,000	
- landscape design	5,000	
- Total Education/Demonstration		$ 273,750

(3) Total Design, Demonstration and Education Costs $ 386,750

The Saskatchewan Housing Corporation also provided guaranteed mortgages for the builders to a total of over one million dollars.

Appendix B

- Project Design Criteria -

Rather than prescribe insulation levels and other mandatory low energy features, builders were given broadly stated design objectives, with the exception of a specific energy budget. This approach allowed the builders considerable freedom in their designs and gave the project a wide spectrum of possible solutions to the low energy housing problem.

1. Energy Budget - The annual space heating requirement shall not exceed 20 GJ per 100 m^2 heated floor space (including basement). This works out to 33.3 KJ/[DD-m^2] or 5 kwh per ft^2/yr.

2. Solar Heating - Designs should make maximum use of passive solar potential. Active solar systems may be considered.

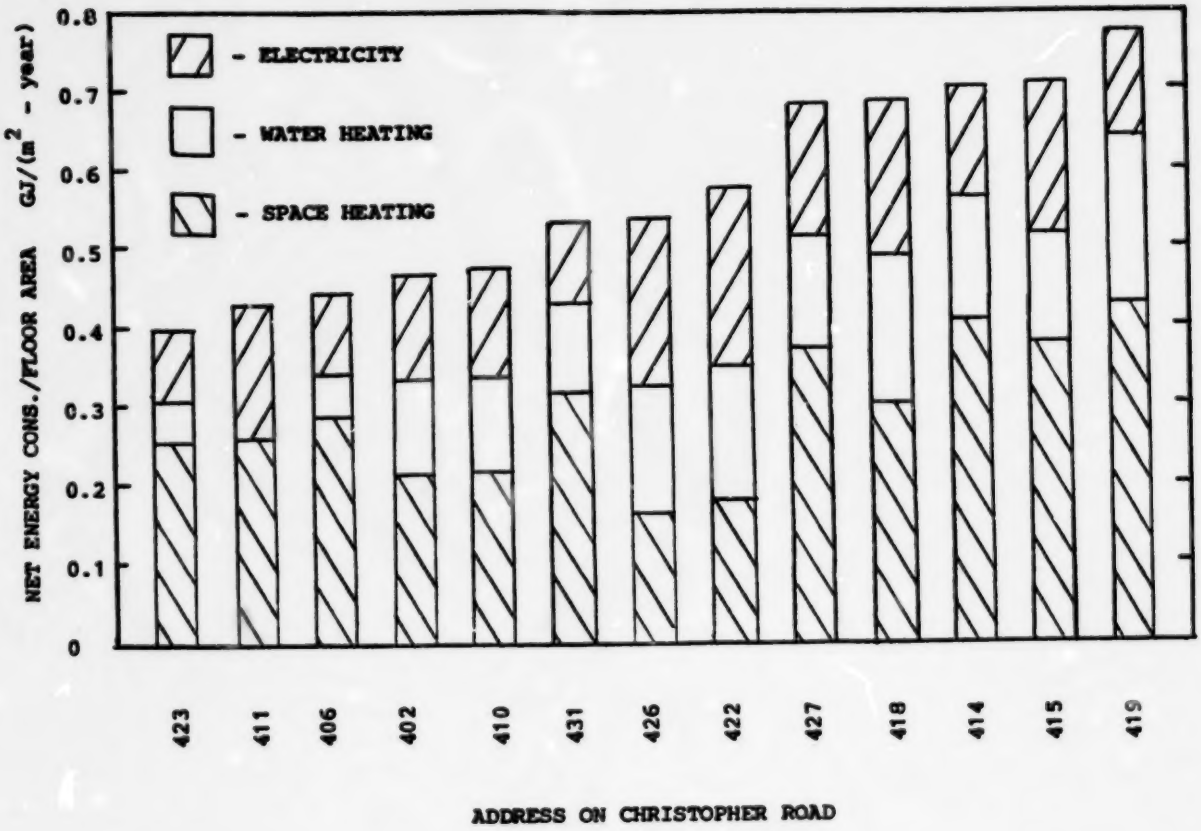
3. Insulation Values - Values will be dictated by the requirements of the energy budget, but must at a minimum be those prescribed by "Measures for Energy Conservation in New Buildings". These are RSI 3.5 for walls, RSI 6.1 for attics and RSI 1.4 for the full basement walls.

4. Air Management - Designs must take into account and solve for potential odour, moisture, toxic gas and increased radon level problems which may arise in tightly sealed houses.

5. Land Use Planning - The project must take into account the established principles of energy efficiency in land use planning including proper east-west street orientation, building siting and orientation to maximize passive solar gain, minimize southern shading ("solar easement") and proper landscaping.

Appendix C

- Total Energy Use of Project Houses -



based on R. S. Dumont, "Energy Consumption Measurements - Energy Showcase Project"

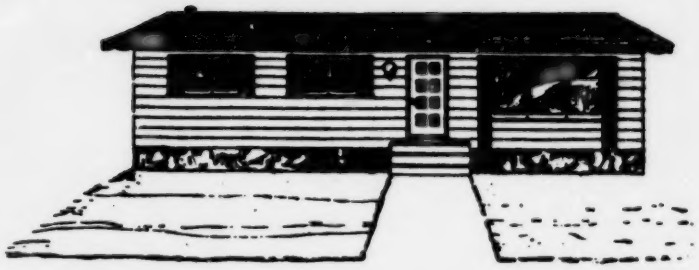
Appendix D

- Low Energy Features and Performance of Project Houses -

The houses in the project represented a wide variety of approaches to low energy performance. While some focused more on the energy conservation aspects, others attempted to make maximum use of the passive solar energy. Most, however, used some combination of these approaches. All of the houses had many features in common. Higher than standard insulation levels were achieved in most building components. Air-tight vapour barriers were regarded as essential for success. Consequently all houses also incorporated some form of air management and waste heat recovery through the use of air to air heat exchangers.

Variations in energy requirements for space heating must be expected. Not only are the houses of significantly different design and construction but the life style of the occupants is one of the most crucial elements in residential energy use.

The data provided in the tables below is collected from a number of sources. The nominal insulation levels given were those specified by the contractors in their original plans. The heat loss calculated for each building component and actual space heat energy required were results of Dr. R. W. Besant's monitering program. The air change rate per hour at 50 Pascals pressure (ACH at 50 Pa) was determined by field testing undertaken by Dr. R. Dumont of the National Research Council. The major low energy features described are those emphasized by the individual building contractors in the fact sheets prepared for the project.



430 Christopher Road
109 square metres (1,176 sq. ft.)
bungalow

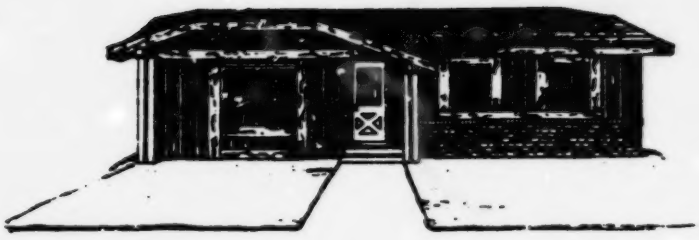
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	10.6		17.2
Walls	7.7		6.5
Doors	4.2		0.5
Basement above grade	7.0		2.2
Basement below grade	5.0		5.0
Basement floor	0.0		42.3
Windows - South	0.78	7.4 m^2	
- Non-S	0.45	4.2 m^2	15.7
Air Tightness	.53	ACH at 50 Pa	10.5

Actual Space Heat Energy Consumed - NRC test house; no data

Major Low Energy Features

- Double wall construction has been utilized, with air-vapour barrier in the wall.
- Window systems include tri-pane clip on window units, with quad sealed units on south windows.
- Furnace room has been carefully sealed and insulated. This encloses heating equipment and reduces air infiltration.
- Double insulated steel doors used at each entrance.



426 Christopher Road
120 square metres (1,292 sq. ft.)
bungalow

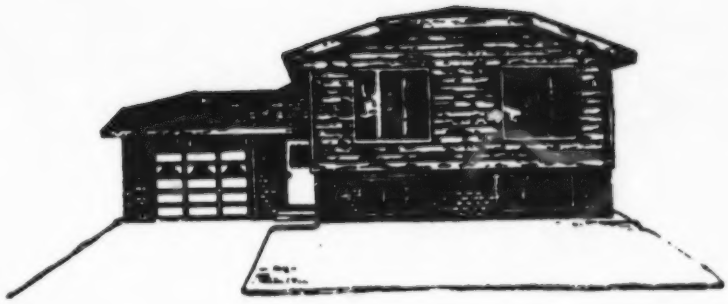
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	10.6		6.6
Walls	10.6		4.8
Doors	4.2		0.6
Basement above grade	4.5		3.2
Basement below grade	3.5		7.2
Basement floor	0.0		44.6
Windows - South	0.78	6.3 m^2	
- Non-S	0.78	3.4 m^2	10.5
Air Tightness	.37	ACH at 50 Pa	22.4

Actual Space Heat Energy Consumed - 24.9 (KJ/DD-m^2)

Major Low Energy Features

- Double wall construction has been utilized, with the air-vapour barrier in the wall.
- Space heat provided by hot water coil/fan unit supplied by domestic hot water heater.
- Quad glazing used on all windows.
- Wall mounted electrical fixtures reduce potential damage to ceiling air-vapour barrier.



422 Christopher Road
112 square metres (1,206 sq. ft.)
bi-level

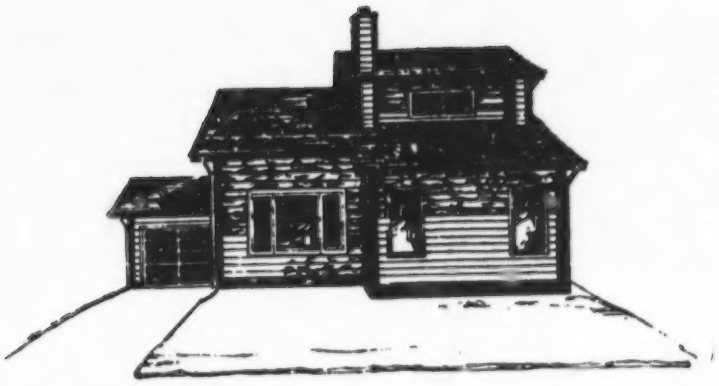
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	8.8		12.8
Walls	6.0		7.2
Doors	4.2		0.5
Basement above grade	9.5		2.9
Basement below grade	3.9		2.5
Basement floor	0.0		41.2
Windows - South	0.45	9.5 m^2	
- Non-S	0.45	7.3 m^2	22.2
Air Tightness	1.09	ACH at 50 Pa	10.7

Actual Space Heat Energy Consumed - 28.6 (KJ/DD-m^2)

Major Low Energy Features

- Double wall construction has been utilized, with poly-pans to seal electrical outlets.
- Vestibules at front and rear doors reduce entrance heat losses.
- Pre-heat hot water tank speeds recovery time for the hot water heater.
- Down-sized furnace used with the reduced space heat requirements.



418 Christopher Road
130 square metres (1,400 sq. ft.)
5 level split

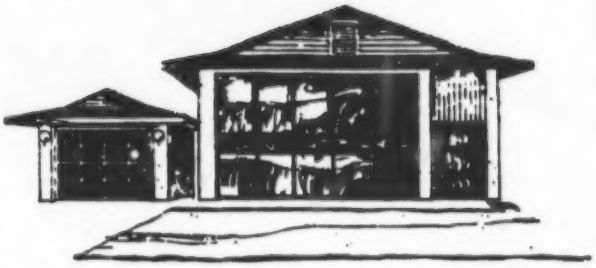
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	10.6		6.2
Walls	7.0		11.6
Doors	2.1		1.1
Basement above grade	5.6		1.6
Basement below grade	3.8		5.0
Basement floor	0.0		35.0
Windows - South	0.57	8.1 m^2	
- Non-S	0.45	2.6 m^2	14.4
Air Tightness	0.76	ACH at 50 Pa	25.1

Actual Space Heat Energy Consumed - 41.9 ($KJ/DD-m^2$)

Major Low Energy Features

- Double wall construction was utilized to achieve high insulation levels with the air-vapour barrier in the wall.
- Windows in the house are all triple glazed units.
- The fireplace is equipped with glass doors and is provided with combustion air from outside to minimize air infiltration.
- Electrical fixtures have been mounted on walls to reduce penetrations of the ceiling air-vapour barrier.



414 Christopher Road
85 square metres (914 sq. ft.)
bi-level

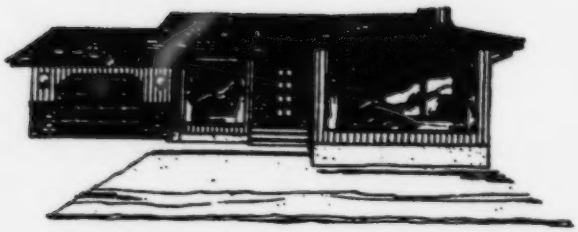
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	10.5		5.1
Walls	7.0		5.0
Doors	2.1		1.1
Basement above grade	7.0		4.4
Basement below grade	7.0		2.4
Basement floor	0.0		31.2
Windows - South	0.36	16.4 m^2 *	
- Non-S	0.45	3.3 m^2	35.7
Air Tightness	2.19	ACH at 50 Pa	15.1

Actual Space Heat Energy Consumed - 85.4 (KJ/DD-m^2)

Major Low Energy Features

- Hot water baseboard heaters supplied from the domestic hot water heater, provide space heat.
- A vestibule is incorporated to reduce entrance heat loss.
- Truss frame system allows for greater floor span and gives space for ducting and heating equipment.
- A Trombe wall and insulated curtain (*) on south windows maximize passive solar gain.



410 Christopher Road
106 square metres (1,142 sq. ft.)
bungalow

Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	8.8		7.6
Walls	5.3		8.5
Doors	2.1		1.0
Basement above grade	5.3		2.4
Basement below grade	5.3		5.6
Basement floor	0.0		47.7
Windows - South	0.54	9.0 m^2	
- Non-S	0.45	3.3 m^2	17.4
Air Tightness	0.77	ACH at 50 Pa	10.0

Actual Space Heat Energy Consumed - 50.6 (KJ/DD-m^2)

Major Low Energy Features

- Strapped wall construction used allows high insulation and a buried vapour barrier on a single stud wall.
- Wall mounted electrical fixtures reduce the number of ceiling vapour barrier penetrations.
- A sealed furnace room with exterior air supply reduces the ventilation requirements of the house.
- The fireplace has glass doors and an exterior fresh air supply to reduce air infiltration.

406 Christopher Road
98 square metres (1,050 sq. ft.)
bungalow

Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	10.6		7.4
Walls	7.7		6.9
Doors	2.1		1.1
Basement above grade	4.9		3.3
Basement below grade	3.9		7.1
Basement floor	0.0		38.0
Windows - South	0.57	7.8 m^2	
- Non-S	0.57	3.4 m^2	15.9
Air Tightness	0.62	ACH at 50 Pa	20.3

Actual Space Heat Energy Consumed - 42.3 (KJ/DD-m^2)

Major Low Energy Features

- Strapped wall of 2 X 6 stud wall with horizontal 2 X 3 allows good insulation levels and buried air-vapour barrier.
- Wall mounted electrical fixtures reduce penetrations of ceiling vapour barrier.
- Gas furnace is sealed into a closed furnace room with exterior combustion air supply.
- A vestibule reduces heat loss at the entrance.

402 Christopher Road
109 square metres (1,173 sq. ft.)
bungalow

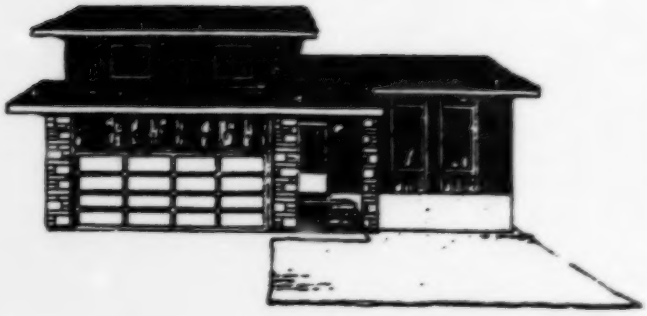
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	8.6		6.6
Walls	5.3		6.9
Doors	1.0		2.7
Basement above grade	3.9		3.2
Basement below grade	3.9		5.3
Basement floor	0.0		49.2
Windows - South	0.37	7.4 m^2	
- Non-S	0.45	3.9 m^2	17.9
Air Tightness	0.45	ACH at 50 Pa	8.3

Actual Space Heat Energy Consumed - 71.9 ($KJ/DD-m^2$)

Major Low Energy Features

- Solarium provides greenhouse space or acts as solar pre-heater.
- An overheat ventilation system draws excess heat from the main floor and dumps it into the basement.
- Poly-pans used to seal electrical penetrations of the air-vapour barrier.
- Sealed furnace room with exterior air supply reduces house ventilation requirements.



411 Christopher Road
103 square metres (1,110 sq. ft.)
4 split level

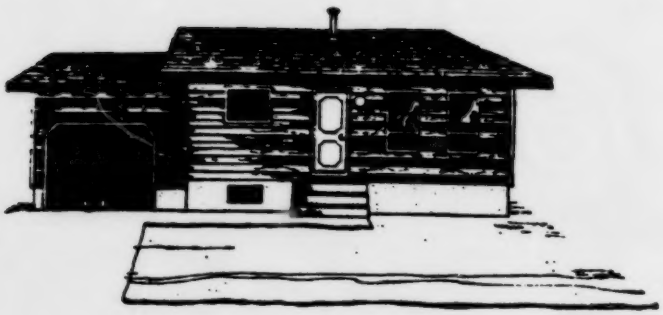
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	10.6		7.1
Walls	6.7		10.8
Doors	4.2		0.8
Basement above grade	3.5		3.9
Basement below grade	3.5		3.0
Basement floor	0.0		45.4
Windows - South	0.57	10.4 m^2	
- Non-S	0.45	4.7 m^2 *	19.1
Air Tightness	1.04	ACH at 50 Pa	9.9

Actual Space Heat Energy Consumed - no data available

Major Low Energy Features

- A power vent furnace installed in the garage instead of the basement.
- North windows equipped with beadwall insulating shutters (*).
- Automatic timer on hot water heater controls heating cycle of water tank.
- Perimeter of third level floor insulated with extruded polystyrene.



415 Christopher Road
126 square metres (1,365 sq. ft.)
4 level split

Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	8.8		6.4
Walls	5.3		7.1
Doors	2.1		1.2
Basement above grade	9.5		3.3
Basement below grade	3.9		5.5
Basement floor	0.0		33.6
Windows - South	0.36	7.8 m^2	
- Non-S	0.36	2.4 m^2	21.7
Air Tightness	1.14	ACH at 50 Pa	21.2

Actual Space Heat Energy Consumed - 81.4 (KJ/DD-m^2)

Major Low Energy Features

- A vestibule reduces heat loss at the entrance.
- Poly-pans are used behind electrical outlets to maintain the integrity of the air-vapour barrier.
- A pre-heat tank reduces the recovery time for the hot water heater.

419 Christopher Road
115 square metres (1,238 sq. ft.)
split level

Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	8.8		6.2
Walls	5.3		8.3
Doors	2.1		0.7
Basement above grade	6.7		3.9
Basement below grade	4.9		3.7
Basement floor	0.0		41.3
Windows - South	0.36	15.8 m^2 *	
- Non-S	0.45	2.1 m^2	24.3
Air Tightness	1.31	ACH at 50 Pa	11.6

Actual Space Heat Energy Consumed - 69.6 (KJ/DD-m^2)

Major Low Energy Features

- Pressure treated wood foundation makes basement insulation easier, while the wood floor adds comfort.
- Trombe wall and insulating curtain (*) aid solar gain.
- Pre-heat tank reduces recovery time for the hot water heater.
- Exterior attic access hatch reduces air infiltration.
- A greenhouse is incorporated into the design of the house.

423 Christopher Road
113 square metres (1,216 sq. ft.)
split level

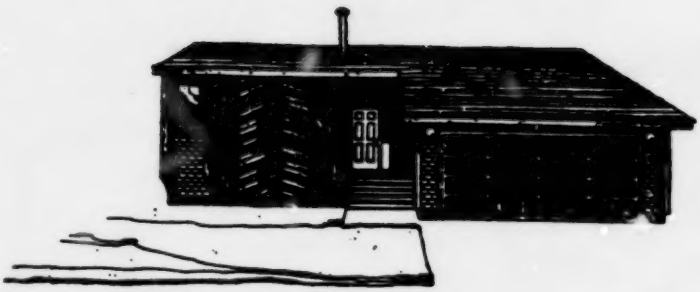
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	7.0		15.7
Walls	7.0		11.7
Doors	4.2		0.7
Basement above grade	7.0		1.0
Basement below grade	4.9		5.6
Basement floor	0.0		40.1
Windows - South	0.58	8.4 m^2	
- Non-S	0.48	3.1 m^2	15.2
Air Tightness	0.76	ACH at 50 Pa	9.9

Actual Space Heat Energy Consumed - 58.8 (KJ/DD-m^2)

Major Low Energy Features

- Double wall construction allows high insulation levels and a buried air-vapour barrier.
- Air tight furnace room with exterior combustion air supply reduces house ventilation requirements.
- The use of two insulated doors at each entrance reduces heat loss.
- Rigid fibreglass insulation on basement exterior also acts as a drainage layer.



427 Christopher Road
107 square metres (1,150 sq. ft.)
bi-level

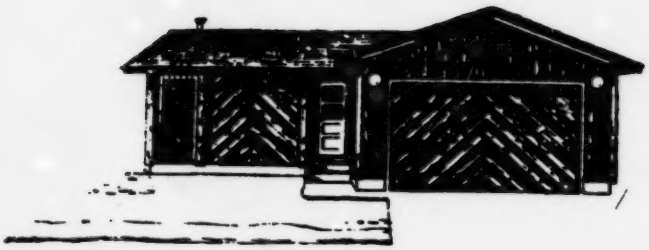
Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	8.8		6.4
Walls	5.3		5.3
Doors	2.1		0.6
Basement above grade	4.9		5.5
Basement below grade	3.5		2.6
Basement floor	0.0		39.7
Windows - South	0.57	15.7 m^2	
- Non-S	0.45	6.7 m^2	24.6
Air Tightness	0.54	ACH at 50 Pa	15.3

Actual Space Heat Energy Consumed - 68.6 (KJ/DD-m^2)

Major Low Energy Features

- Single wall construction with exterior rigid insulation has been used on this house.
- Window location maximizes passive solar gain.
- A vestibule reduces heat loss at the entrance.
- A sealed furnace room with exterior combustion air supply reduces house ventilation requirements.



431 Christopher Road
115 square metres (1,238 sq. ft.) bungalow

Insulation Levels, Air Tightness and Performance

Item	Value (RSI)		% of space heating loss
Ceiling	10.6		6.8
Walls	7.0		5.6
Doors	1.2		2.0
Basement above grade	5.6		2.1
Basement below grade	5.6		5.8
Basement floor	0.0		43.7
Windows - South	0.50	9.6 m^2	
- Non-S	0.45	2.3 m^2	20.3
Air Tightness	0.74	ACH at 50 Pa	12.2

Actual Space Heat Energy Consumed - 44.5 (KJ/DD-m^2)

Major Low Energy Features

- Double wall construction used allows high insulation levels and a buried air-vapour barrier.
- A vestibule reduces entrance heat losses.
- Large south windows maximizes use of passive solar energy.
- A sealed furnace room with exterior combustion air supply reduces house ventilation requirements.

Appendix E

- Weather Data for Saskatoon (lat 52° 6') -

	Mean Temp. (°C)	Heating Degree Days (18°C Base)	Mean Wind Speed (km/hr)	Total** Bright Sunshine (hr)	Percent Possible Bright Sunshine	Total Global Radiation (MJ/m^2)
Mar '81	-1.5(-7.9)*	594(803)	11.3(18.0)	183(192)	50(52)	386(423)
Apr	5.5(3.4)	373(433)	15.9(18.0)	253(225)	61(54)	507(519)
May	12.5(11.2)	178(214)	16.9(20.3)	205(278)	42(58)	666(659)
June	15.0(15.6)	97(96)	13.2(18.7)	299(280)	65(56)	639(683)
July	19.0(19.1)	21(28)	12.0(17.1)	301(341)	60(68)	630(737)
Aug	20.5(17.7)	14(43)	11.0(16.7)	317(294)	70(65)	580(604)
Sept	13.5(11.3)	160(197)	13.4(19.0)	200(207)	63(55)	390(410)
Oct	3.0(5.4)	462(407)	16.0(18.7)	104(175)	32(53)	198(256)
Nov	0.5(-5.4)	531(713)	12.7(17.9)	115(98)	44(37)	115(129)
Dec	-13.0(-13.8)	969(967)	12.8(17.4)	100(84)	42(35)	104(97.5)
Jan '82	-26.5(-18.9)	1386(883)	12.5(17.3)	122(99)	48(39)	146(133)
Feb	-10.5(-14.1)	950(928)	13.7(16.4)	141(129)	51(47)	219(233)
Mar	-8.0(-8.3)	812(803)	15.6(18.0)	157(192)	43(52)	379(423)

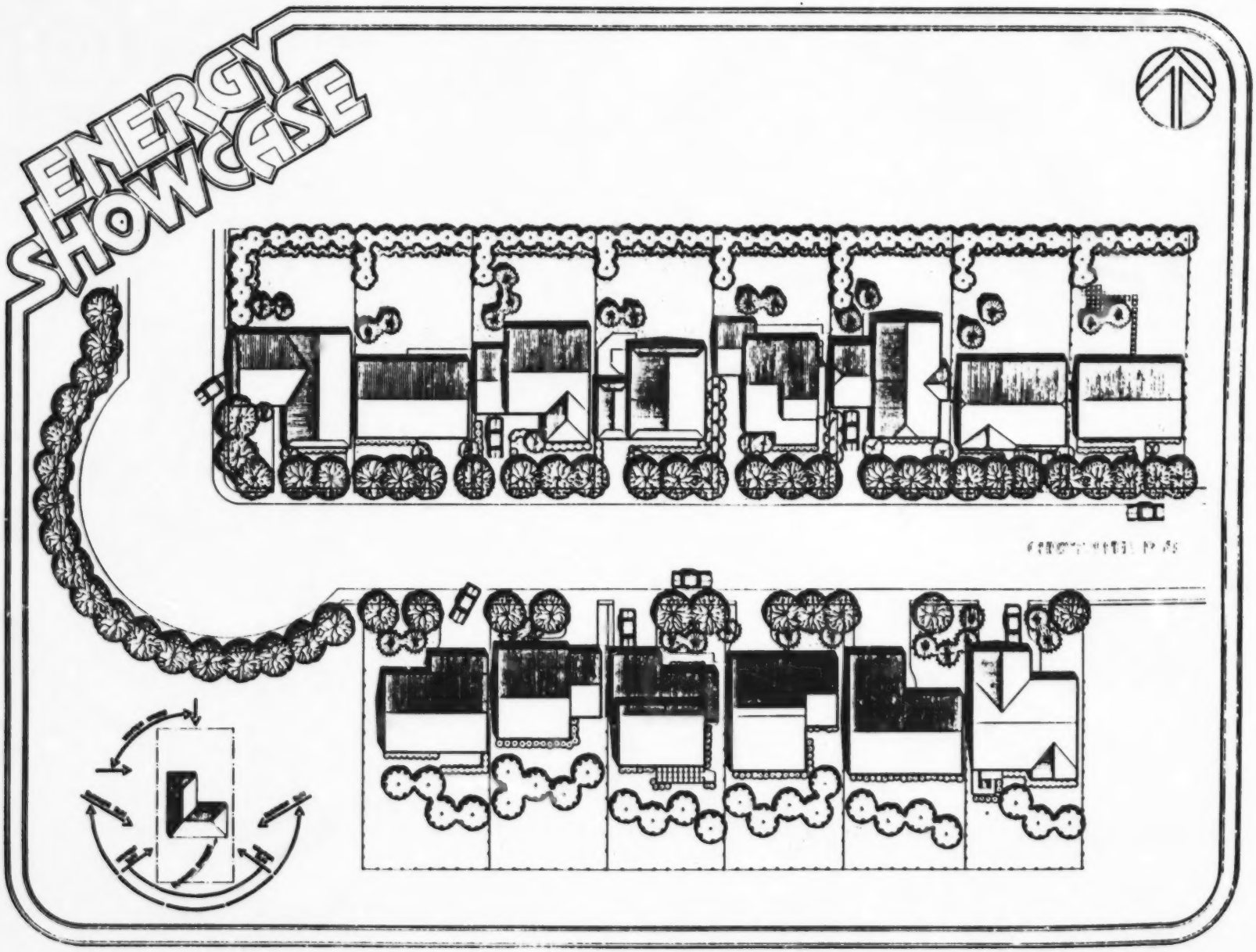
* Longterm average values in brackets

** Stokes-Campbell Measurement

Appendix F

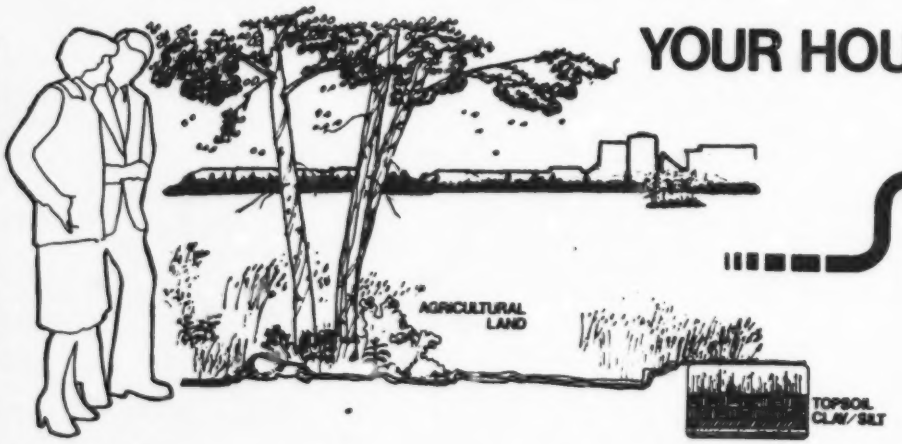
Low Energy Landscaping and Site Planning

Prepared by D. Clark, Underwood McLelland

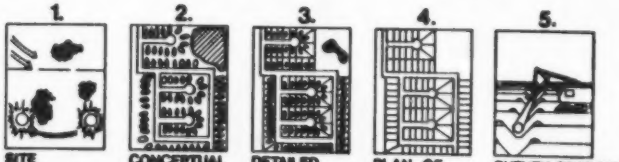

ENERGY
SHOWCASE

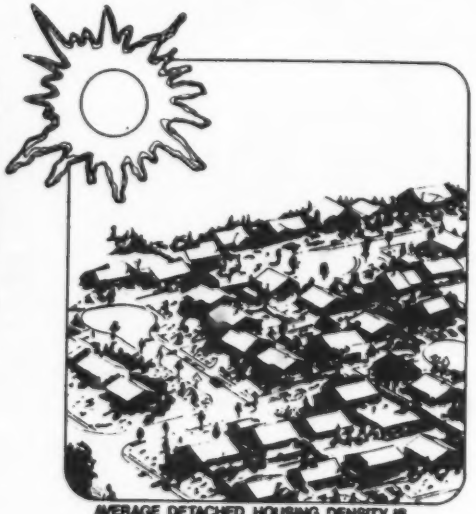
YOUR HOUSING SITE IN SASKATOON

THE SITE SELECTION PROCESS

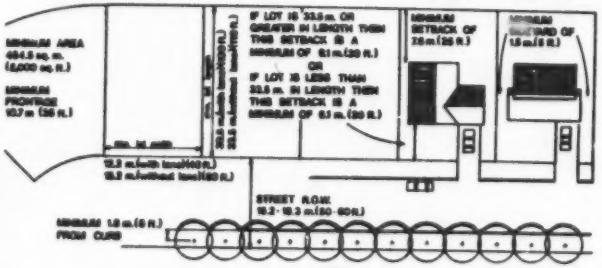


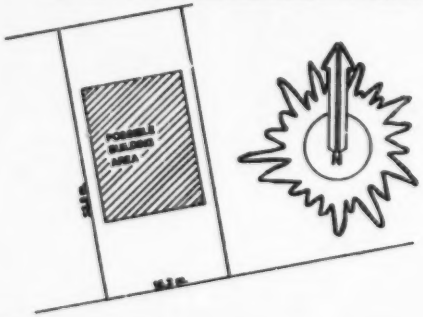
THE DEVELOPMENT PROCESS



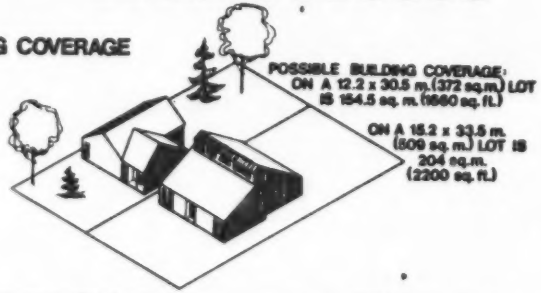


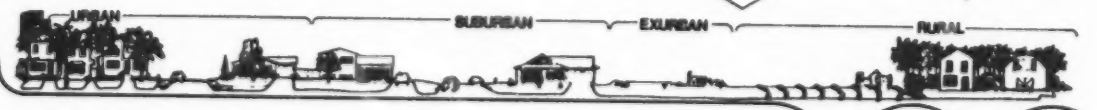
CITY BY-LAWS AND SITE DEVELOPMENT REGULATIONS


MINIMUM AREA
464.5 sq. m.
(5,000 sq. ft.)
MINIMUM FRONTAGE
10.7 m (35 ft.)
IF LOT IS 33.5 m. OR GREATER IN LENGTH THEN THIS SETBACK IS A MINIMUM OF 6.1 m (20 ft.)
OR
IF LOT IS LESS THAN 33.5 m. IN LENGTH THEN THIS SETBACK IS A MINIMUM OF 6.1 m (20 ft.)
MINIMUM SETBACK OF 7.5 m (25 ft.)
MINIMUM SIDEYARD OF 1.5 m (5 ft.)
STREET R.O.W.
18.2 - 19.2 m (60 - 63 ft.)
MINIMUM 1.5 m (5 ft.) FROM CURB



BUILDING COVERAGE





ENERGY EFFICIENT RESIDENTIAL LANDSCAPE DESIGN

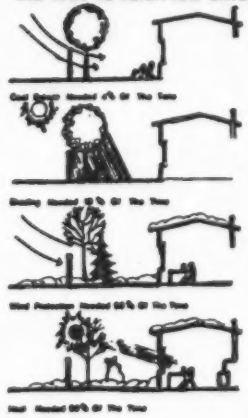
1

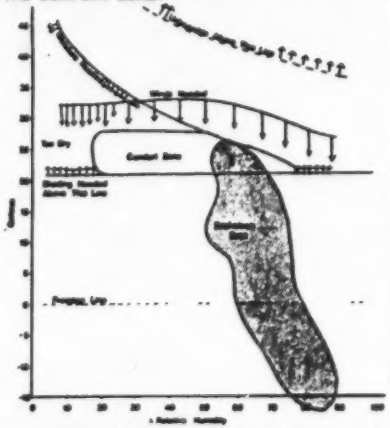
BUILDING SHAPE AND ORIENTATION

CLIMATIC ANALYSIS · SASKATOON 52°7′N.

HUMAN COMFORT ZONE

HUMAN BEINGS STRIVE FOR THE POINT AT WHICH A MINIMUM EXPENDITURE OF ENERGY IS NEEDED TO ADJUST TO THE ENVIRONMENT. CONDITIONS UNDER WHICH ONE SUCCEEDS IN DOING THIS CAN BE DEFINED AS THE 'COMFORT ZONE.' WHILE THE CONSTRUCTION OF A SHELTER IS THE MAIN INSTRUMENT FOR FULFILLING THESE REQUIREMENTS, OUTDOOR SPACE, A FUNCTION OF ① AIR TEMPERATURE ② RADIATION ③ AIR MOVEMENT ④ HUMIDITY, MUST BE HANDLED IN DIFFERING WAYS TO ALTER AND EXTEND THE COMFORT ZONE.





IN ACCORDANCE WITH THE CODES AND REGULATIONS, BUILDING ORIENTATION SHOULD ALSO BE RESPONSIVE TO:

- ① LOCAL TOPOGRAPHY
- ② REQUIREMENT FOR PRIVATE OUTDOOR AND INTERNAL SPACE
- ③ PLEASURABLE VIEWS
- ④ CLIMATIC FACTORS OF WIND AND SOLAR ORIENTATION

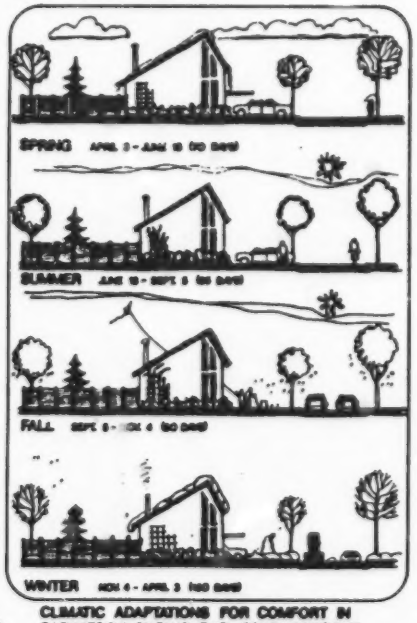
IN THE COOL ZONE

HEAT CONSERVATION IS THE MAIN OBJECTIVE, ORIENTATION THEREFORE SHOULD BE SOMEWHAT EAST OF SOUTH

OPTIMUM HOUSE SHAPE:

THERMAL FORCES ACTING ON THE WALLS OF A HOUSE ADD AND SUBTRACT UNITS OF HEAT THROUGHOUT THE SEASON. STUDIES SUGGEST THAT IN A COLD CLIMATE, WHERE HEAT LOSS IS 2-3 TIMES GREATER THAN HEAT GAIN, THE OPTIMUM SHAPE FOR HOUSE CONSTRUCTION IS:

A RATIO OF 1.0 : 1.3



CLIMATIC ADAPTATIONS FOR COMFORT IN SASKATOON DURING THE FOUR SEASONS

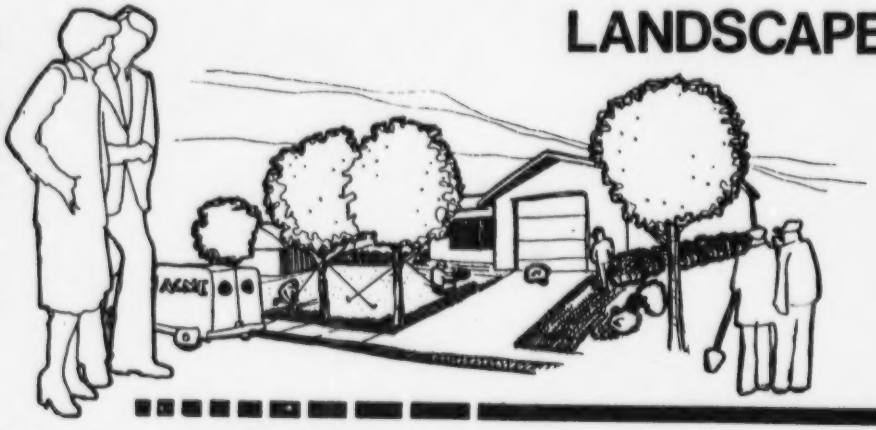
TEMPERATURE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
AVERAGE MEAN AIR TEMPERATURE	-17.2°C	-15.0°	-7.9°	3.7°	11.4°	15.4°	17.2°	17.5°	11.6°	5.5°	-2.5°	-13.5°
% OF THE DAILY AIR TEMP. IS BELOW 0°C	97%	90%	71%	39%	10%	1%	0%	2%	10%	30%	68%	92%
SOIL TEMPERATURE AT 10 cm DEPTH	-11.1°C	-7.6°	-3.9°	1.7°	10.0°	15.0°	17.1°	16.5°	12.8°	5.9°	-2.8°	-6.7°
SOIL TEMPERATURE AT 30 cm DEPTH	-7.6°C	-4.4°	-2.2°	1.5°	7.6°	12.2°	15.0°	14.9°	11.7°	6.1°	-1.1°	-2.2°
CLOUD - SUNSHINE - SOLAR RADIATION												
AVERAGE FREQUENCY OF CLOUD COVER	78%	76%	75%	61%	61%	66%	50%	55%	59%	54%	60%	79%
AVERAGE SUNSHINE HOURS/DAY	3.4 h	4.5	6.4	7.5	9.1	9.0	11.4	9.0	6.0	3.7	3.4	2.7
AVG. % OF MAXIMUM SUNSHINE POSSIBLE	30%	47%	52%	54%	76%	75%	82%	69%	94%	99%	98%	99%
AVG. DAILY SOLAR RADIATION LANGLEYS/DAY	100	200	320	410	540	570	567	479	320	220	120	90
AVG. % OF MAX. POSSIBLE SOLAR RADIATION	30%	63%	66%	97%	96%	99%	98%	97%	91%	90%	49%	47%
AVERAGE TOTAL PRECIPITATION IN CM.	1.9	1.9	1.4	1.9	3.1	6.1	9.0	2.9	2.9	1.9	1.9	1.6
RELATIVE HUMIDITY	76%	78%	76%	69%	59%	76%	97%	90%	69%	69%	79%	76%
PREVAILING WIND DIRECTION	SW	WSW	WSW	WSW	SE	NNW	NNW	NNW	NNW	NNW	NNW	SW
STRONGEST WIND DIRECTION	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW	NNW

ENERGY EFFICIENT RESIDENTIAL LANDSCAPE DESIGN

2

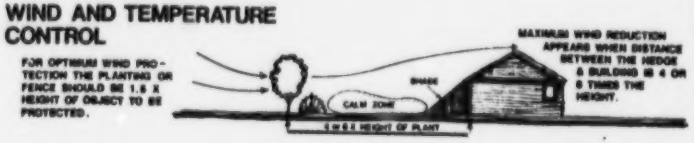
LANDSCAPE DESIGN - "A KIT OF PARTS"

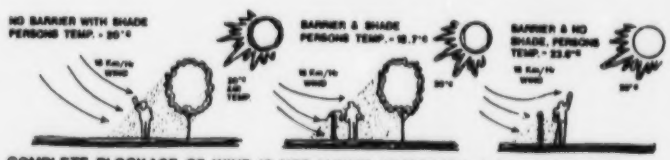
SITE ANALYSIS



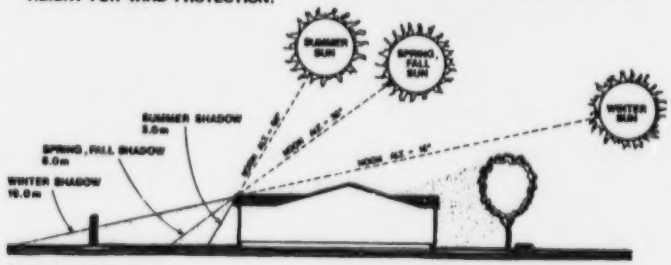
THE COMPONENTS

WIND AND TEMPERATURE CONTROL

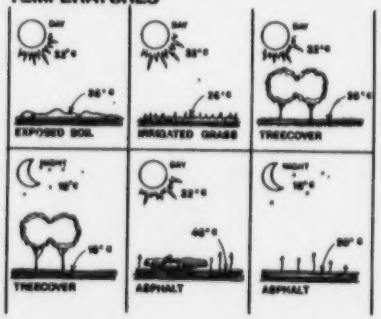

FOR OPTIMUM WIND PROTECTION THE PLANTING OR FENCE SHOULD BE 1.5 X HEIGHT OF OBJECT TO BE PROTECTED.
MAXIMUM WIND REDUCTION APPEARS WHEN DISTANCE BETWEEN THE HEDGE & BUILDING IS 4 OR 6 TIMES THE HEIGHT.
CALM ZONE
SHADE
5 M 6 X HEIGHT OF PLANT

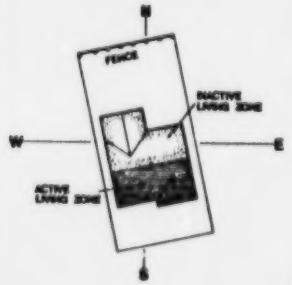

NO BARRIER WITH SHADE PERSONS TEMP. - 30°C
BARRIER & SHADE PERSONS TEMP. - 18.7°C
BARRIER & NO SHADE, PERSONS TEMP. - 23.6°C
18 Km/Hr WIND
30° AIR TEMP.

COMPLETE BLOCKAGE OF WIND IS NOT ALWAYS NECESSARY. A 9.0m BACK YARD SPACE WOULD REQUIRE A HEDGE OR CONSTRUCTED BARRIER OF 1.5 - 2.3m IN HEIGHT FOR WIND PROTECTION.



TEMPERATURES





OBJECTIVES OF SITE DEVELOPMENT

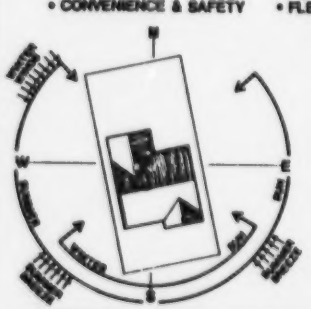
① FOR ENERGY CONSERVATION

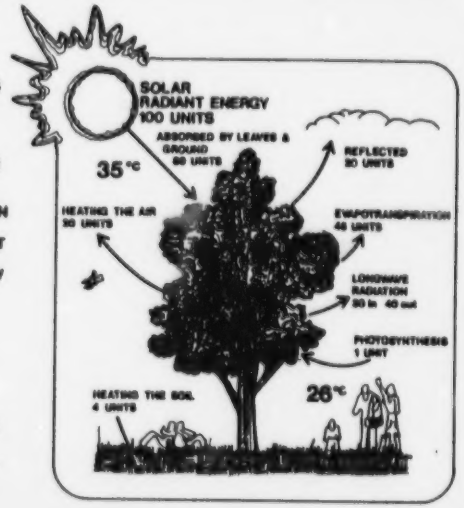
A. (MAXIMIZE WARMING EFFECTS OF SOLAR RADIATION)
- UTILIZE SOUTH TO SOUTHEAST OR SOUTHWEST FACING SITES
- ORIENT ACTIVE LIVING AREAS TO THE SOUTH TO TAKE FULL ADVANTAGE OF WINTER SUN.
- CREATE PROTECTED SUN POCKETS.
- UTILIZE DARKER COLORS WHICH ABSORB RADIATION.
- UTILIZE EXTERIOR WALLS & FENCES TO CAPTURE THE WINTER SUN & REFLECT WARMTH INTO LIVING SPACES.

B. (REDUCE IMPACT OF COLD WINTER WINDS)
- IF POSSIBLE, LOCATE BUILDINGS ON THE LEE SIDE OF HILLS IN THE WIND SHADOW.
- UTILIZE EVERGREENS, EARTH MOUNDS & FENCES TO PROTECT NORTHERN EXPOSED WALLS.
- UTILIZE SHALLOW PITCHED ROOFS TO COLLECT & HOLD SNOW FOR ADDED INSULATION.

② OWNER GOALS

- IDENTITY
- COMFORT
- CONVENIENCE & SAFETY
- EASE OF MAINTENANCE
- PRIVACY
- FLEXIBILITY





IMPORTANCE OF VEGETATION :

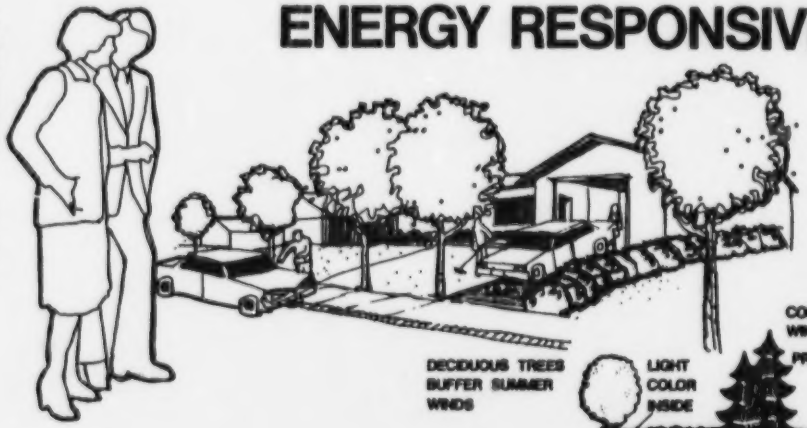
TEMPERATURE & CLIMATE CONTROL, WIND BREAKS, AIR QUALITY, PRECIPITATION & EROSION CONTROL, SOUND CONTROL, DEFINES SPACE & CIRCULATION, CREATES PRIVACY, GLARE & REFLECTION CONTROL, SEASONAL & AESTHETIC FUNCTIONS, PROVIDE FOOD FOR BOTH HUMANS & WILDLIFE

ENERGY EFFICIENT RESIDENTIAL LANDSCAPE DESIGN

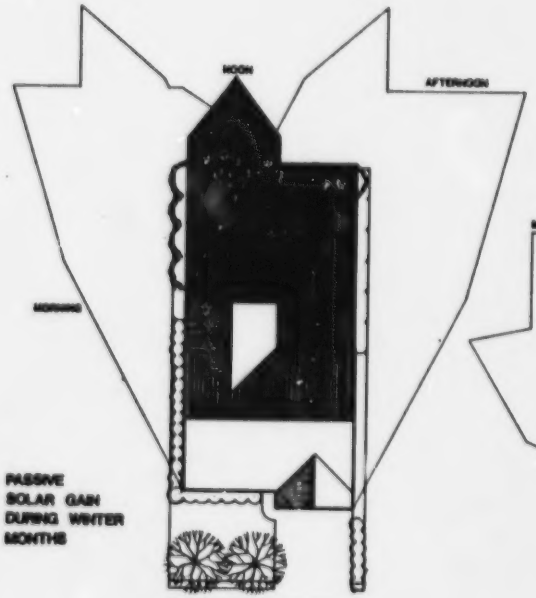
3

SITE DESIGN

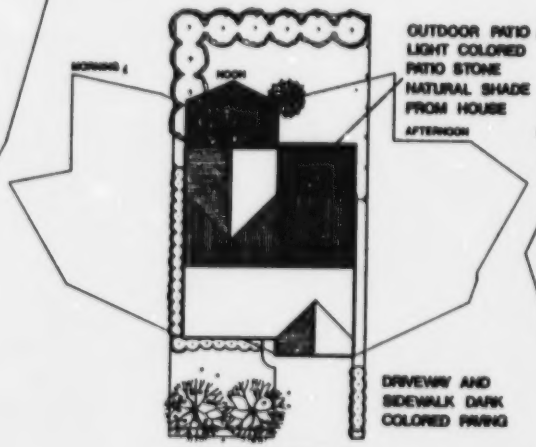
ENERGY RESPONSIVE LANDSCAPE DEVELOPMENT



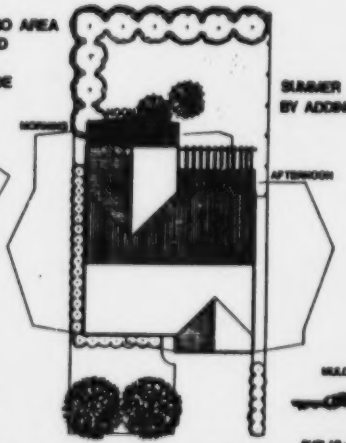
DECIDUOUS TREES BUFFER SUMMER WINDS
CONIFEROUS TREES FOR WIND PROTECTION
PRIVATE OUTDOOR PATIO SPACE
LIGHT COLOR INSIDE
REDUCE SOLAR GAIN ON SOUTH FACE AND SOLAR REFLECTION FROM PAVED SURFACES
HEDGE AND TREE REDUCE HEAT BUILD-UP ON DRIVEWAY
LOUVRED FENCE ALLOWS AIR MOVEMENT AND COOLING DURING SUMMER WHILE PROVIDING SHELTER FROM STRONG WINTER WINDS
VINES AND SHRUBS ALONG WEST WALL REDUCE SOLAR GAIN FROM HOT WESTERN SUN



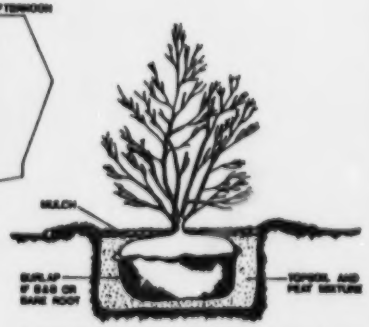
WINTER


MORNING
NOON
AFTERNOON
OUTDOOR PATIO AREA LIGHT COLORED PATIO STONE NATURAL SHADE FROM HOUSE
DRIVEWAY AND SIDEWALK DARK COLORED PAVING

SPRING & FALL



SUMMER



SHRUB BED PLANTING: DETAIL

SHADOW DIAGRAMS

ENERGY EFFICIENT
RESIDENTIAL LANDSCAPE DESIGN

4

Appendix G
- List of Papers and Publications relating to the Project -

Besant, R. W., et al, "Preliminary Computed Space Heating Performance Results for Fourteen Low Energy Passive Solar Houses in Saskatoon, Saskatchewan", Dept. of Mechanical Engineering, University of Saskatchewan, August, 1981. A study of the shortcomings of different heat loss computer models used to predict house energy performance.

Besant, R. W., et al, "A Preliminary Report on the Uninsulated Basement Floor Heat Losses in 14 Low Energy Houses in Saskatoon, Sask.", Dept. of Mechanical Engineering, University of Saskatchewan, July, 1981. The report studies the high heat flow through uninsulated basement floors and discusses the implications this has for low energy house design.

Besant, R. W., et al, "Test Results from a Laboratory Model of an Attic Insulated with Blown Fibreglass", Dept. of Mechanical Engineering, University of Saskatchewan, July, 1981. The report describes tests which showed an inverse relation between temperature differential and apparent thermal resistance across a sample of blown fibreglass insulation. Hypothesis for this behaviour are advanced.

Besant, R. W., et al, "Furnace Performance in the Low Energy Passive Solar Show Homes in Saskatoon", Dept. of Mechanical Engineering, University of Saskatchewan, November, 1981. The report reviews the effect of sealed furnace rooms on the energy transfer efficiency of standard forced air furnaces.

Besant, R. W., et al, "Furnace Performance in the Low Energy Passive Solar Show Homes in Saskatoon", Dept. of Mechanical Engineering, University of Saskatchewan, February, 1982. The report studies the energy transfer efficiency of the space heating furnaces and concludes that more efficient types of space heating devices are required for low energy houses.

Besant, R. W., "Radon Gas Testing Report for Low Energy Houses", Dept. of Mechanical Engineering, University of Saskatchewan, 1981. The report describes the radon testing procedures used and concludes that the radon levels in the showcase houses present no health risk and are well within recognized health standards.

Besant, R. W., et al, "Data Acquisition for the Performance Evaluation of Low Energy Passive Solar Houses", Dept. of Mechanical Engineering, University of Saskatchewan, February, 1982. A description of the three levels of monitoring, overall

fuel use, one time component testing and dynamic data acquisition, and equipment used in the Project.

Besant, R. W., "Report on the Thermal Performance of 14 Low Energy Houses in Saskatoon, Saskatchewan - January 1 to April 2, 1981", Dept. of Mechanical Engineering, University of Saskatchewan, June, 1981. A preliminary report on the monitoring program.

Besant, R. W., et al, "The Measured Performance of Low Energy Passive Solar Houses For 1981 - 1982", Department of Mechanical Engineering, University of Saskatchewan, n.d. The report presents the results of a year long monitoring program of the project. Space heat requirements were between 1/2 and 1/3 of standard houses and a number of component problems were highlighted.

Besant, R. W., et al, "The Measured Performance of Low Energy Passive Solar Houses", Paper presented to 1981 annual conference of the Solar Energy Society of Canada.

Bugg, James, "Air to Air Heat Exchanger Condensation and Frosting Test Results", Dept. of Mechanical Engineering, University of Saskatchewan, June 29, 1981. The study reports on the effect of warm humid air on the operation of a flat plate air to air heat exchanger.

Camera West, "Energy Efficient Homes: The Saskatchewan Approach", 16 mm film sponsored by Saskatchewan Mineral Resources, 1981. An overview of the 14 low energy homes and the project's impact on the building industry.

Clark, D., "Energy Conscious Landscape & Urban Site Design: Saskatoon, Sask. 52°7'", Underwood McLelland, December, 1980. An in-depth review of landscape and urban site factors affecting residential energy use.

Dumont, R. S., et al, "Air Tightness Measurements of Detached Houses in the Saskatoon Area", Draft Copy, National Research Council, Division of Building Research, Prairie Regional Station, Saskatoon, February, 1981. A study of the air tightness of a wide range of house ages, construction styles and materials to determine what factors affect air tightness of building shells. The 14 low energy houses are included in the tests.

Dumont, R. S., "Energy Consumption Measurements - Energy Showcase Project: Nov. 3, 1980 to Nov. 3, 1981", manuscript, n.d. A brief description of energy use in the project. Space heating results are combined with monitored water heating requirements and appliance use to look at the total energy use of the project houses.

Eamer, C., "Saving energy around the house", Westworld, March/April, 1981.

Eamer, C., "Homes on the Range are Canada's Most Energy-Efficient", Habitat, V. 23, #4, 1980.

Eyre, D. and D. Jennings, "Appraisal of the Fourteen Houses in the Saskatoon Project at Mid Design Stage", manuscript, Saskatchewan Research Council, April 7, 1980. A review of the detailed house plans.

Eyre, D. and D. Jennings, "Air-Vapour Barriers", Saskatchewan Research Council, 1981. A report detailing the techniques used to achieve air-tight vapour barriers. Later republished by Energy, Mines and Resources, Canada as "Air-Vapour Barriers: A General Perspective and Guidelines for Installation" in 1982.

Meyer, J. and C. Sieben, "Super Saskatoon", Solar Age, January, 1982. A brief overview of the project.

Mother Earth News, "Saskatoon's Superinsulated Houses", The Mother Earth News, May/June, 1982.

Office of Energy Conservation, Saskatchewan Mineral Resources, "Low Energy House Project - Fact Sheets", n.d. Information sheets for distribution.

Waddell, C., "Energy Savings begin at Home", The Financial Post, n.d., 1981.